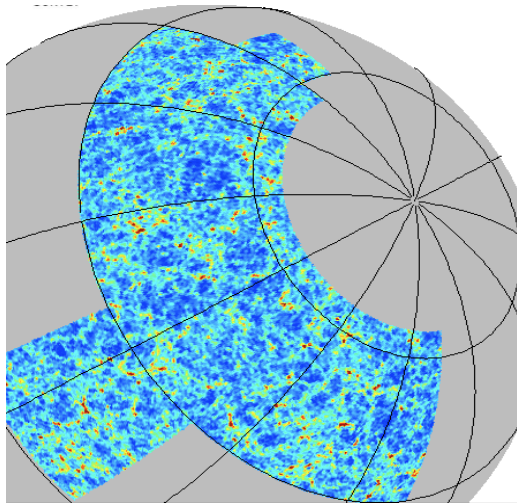




DARK ENERGY
SURVEY

The Dark Energy Survey

status, science, synergies, simulations



LBNL BigBOSS meeting
November 18, 2009

R
isa Wechsler





DARK ENERGY
SURVEY

DES Participating Institutions

13 participating institutions and >100 participants

- **Fermilab**
- **University of Illinois at Urbana-Champaign**
- **University of Chicago**
- **Lawrence Berkeley National Laboratory**
- **University of Michigan**
- **NOAO/CTIO**
- **Spain-DES Collaboration:**
Institut d'Estudis Espacials de Catalunya (IEEC/ICE), Institut de Física d'Altes Energies (IFAE), CIEMAT-Madrid:
- **United Kingdom-DES Collaboration:**
University College London, University of Cambridge, University of Edinburgh, University of Portsmouth, University of Sussex
- **The University of Pennsylvania**
- **Brazil-DES Consortium**
- **The Ohio State University**
- **Argonne National Laboratory**
- **Santa Cruz-SLAC-Stanford Consortium**

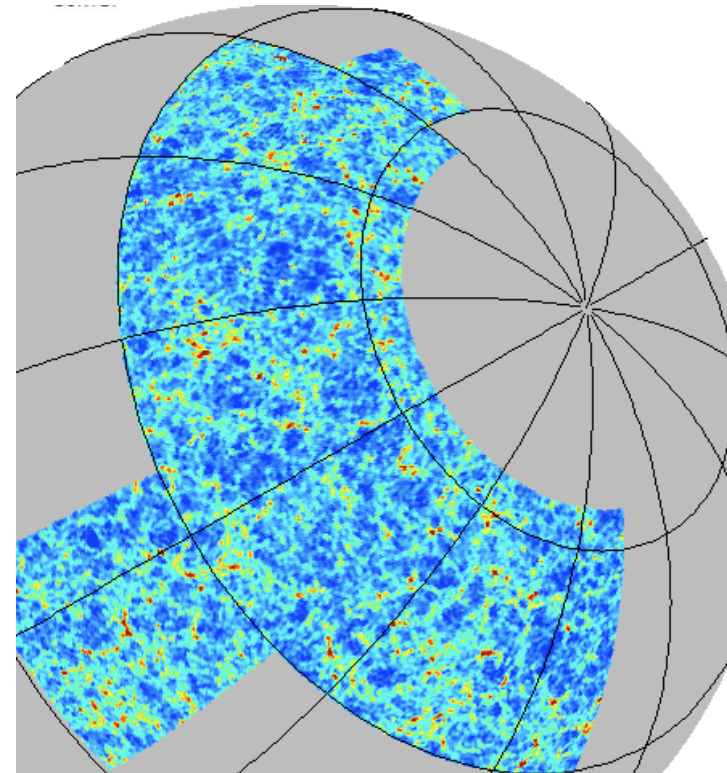


DARK ENERGY
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The Dark Energy Survey

- Basics: 5000 sq. degrees in southern galactic cap, g, r, i, z, Y, four DE probes
- New instrument @ Blanco
 - Replace the prime-focus cage on the CTIO Blanco 4m telescope with a new 2.2 FOV, 520 Mega pixel CCD camera + optics
 - DECam: 3 deg²
 - community pipeline
- Two multi-band surveys
 - 2011-2016 (30%, 525 nights)
 - Main Survey: 5000 sq. degrees
 - SN 1a Survey: 5 fields with 3 deg² each
 - g, r, i, z, Y (DES) + J, H, K (VHS)

Blanco 4-meter @ CTIO





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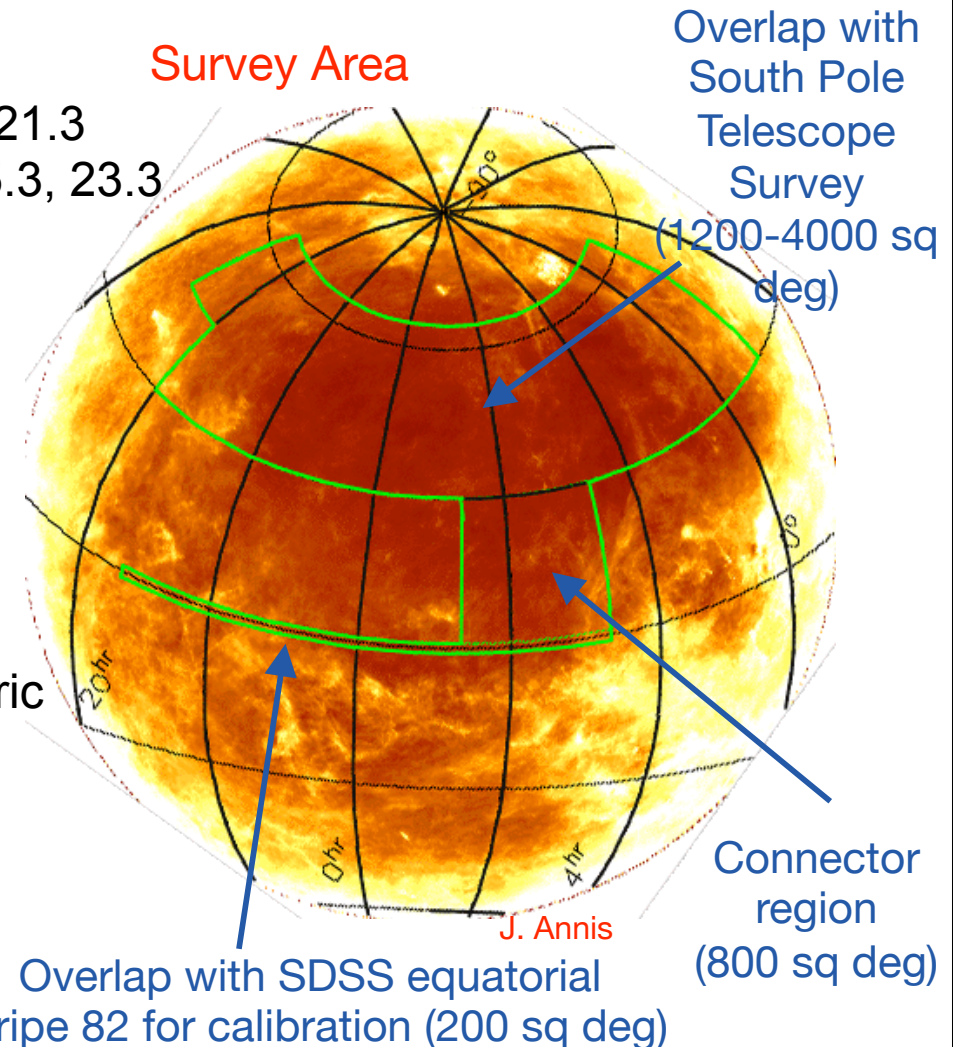
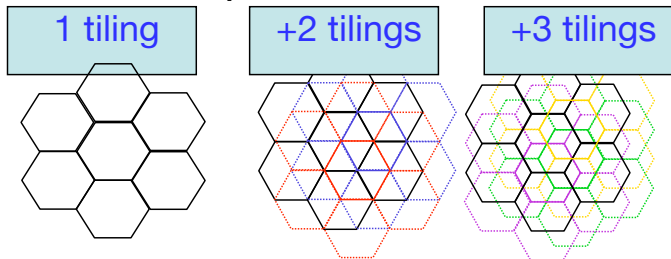
Survey Strategy

Limiting Magnitudes

- Galaxies: 10σ *grizY* = 24.6, 24.1, 24.3, 23.8, 21.3
- Point sources: 5σ *grizY* = 26.1, 25.6, 25.8, 25.3, 23.3
- overlap with SPT (1200-2000 sq. degrees)
- overlap with VISTA J, H, K
- VHS: 20000 deg²: 21.6, 20.6, 20.0;
- VIKING: 1500 deg²: 22.1, 21.5, 21.2

Observation Strategy

- 100 sec exposures
- 2 filters per pointing (typically)
 - gr* in dark time, *izY* in bright time
- Multiple tilings/overlaps to optimize photometric calibrations
- 2 survey tilings/filter/year
- All-sky photometric accuracy
 - Requirement: 2%, Goal: 1%



- DES “tiles” 5000 deg² of sky at a rate of 2 times per year in each of 4 filters



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Dark Energy Survey Schedule

End of 2009: most of the elements are finalizing fabrication.

1st half 2010: last CCDs are selected.

During 2010: All camera elements are sent to FNAL to be integrated and tested in the telescope simulator.

Early 2011: Camera at CTIO: installation.

Summer 2011: Commissioning.

October 2011: Survey starts.



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DES Science Program

Four Probes of Dark Energy

- **Galaxy Clusters**
 - ~100,000 clusters ($M > .8e14$) to $z=1$
 - ~500-2000 with SZ measurements from SPT
 - note that despite the small overlap, cross-calibration can increase FOM by large factor
 - Sensitive to growth of structure and geometry
- **Weak Lensing**
 - Shape measurements of 300 million galaxies
 - Sensitive to growth of structure and geometry
- **Baryon Acoustic Oscillations**
 - 300 million galaxies to $z = 1$ and beyond
 - Sensitive to geometry
- **Supernovae**
 - 15 sq deg time-domain survey
 - ~3000 well-sampled SNe Ia to $z \sim 1$
 - Sensitive to geometry

of course other non-
DE cosmology:
non-Gaussianity,
neutrino masses, etc.

$m_{\nu} < 0.11\text{eV}$
from angular clustering + Planck,
3x Planck alone (Lahav et al 09)



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DES Working Groups

■ Science Committee (Frieman/Lahav)

■ DE working groups

- clusters (Mohr/McKay)
- weak lensing (Jain/Bridle)
- LSS/BAO (Percival/Gastanaga)
- SN (Nichol/Mariner)

■ cross-cutting working groups

- photometric redshifts (Lin/Castander)
- simulations (Evrard/Kravtsov)
- theory/combined probes (Hu/Weller)
- new spectroscopy task force

■ non-DE working groups

- galaxy evolution (Wechsler/Thomas)
- strong lensing (Malaker/Buckley-Greer)
- galactic archaeology (Yanny/Santiago)
- quasars (Martini/McMahan)



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DES Forecasts: Power of Multiple Techniques

$$w(z) = w_0 + w_a(1-a)$$

Assumptions:

Clusters: $\sigma_8=0.75$, $z_{\max}=1.5$,

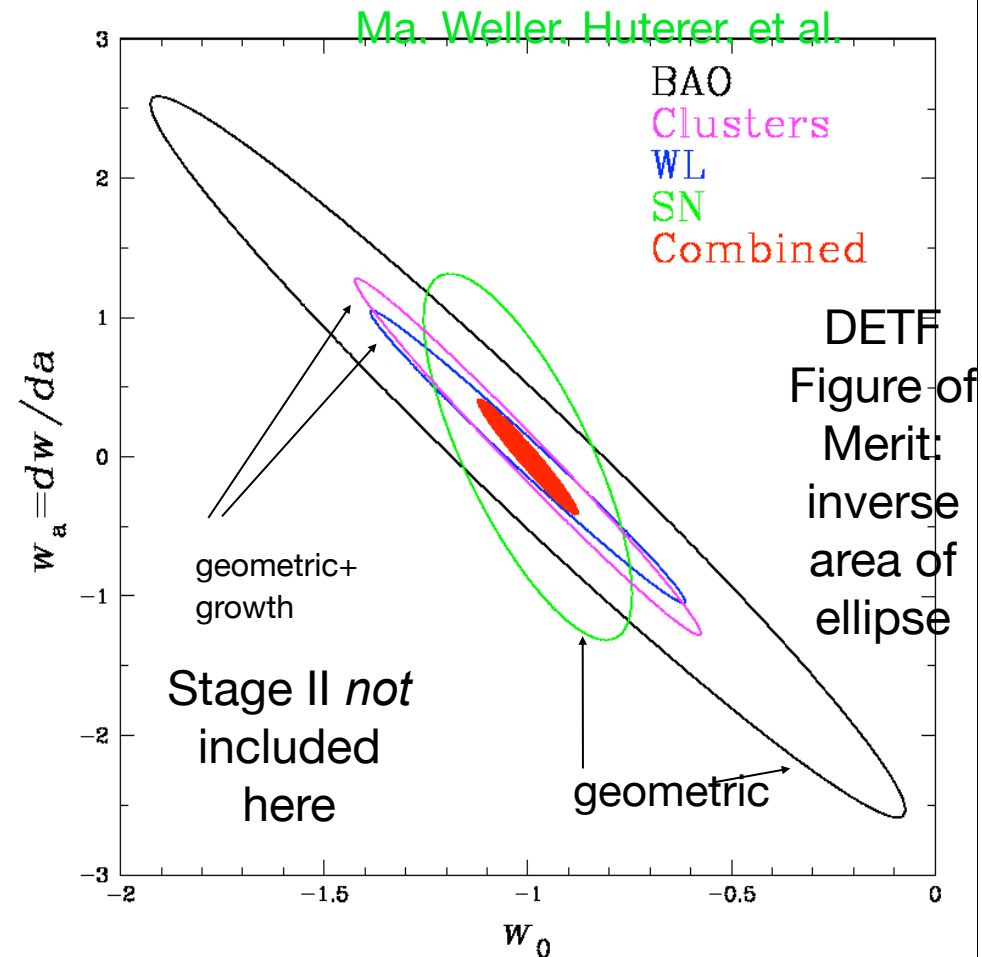
WL mass calibration

BAO: $\ell_{\max}=300$ WL: $\ell_{\max}=1000$

Statistical+photo-z systematic errors only

Spatial curvature, galaxy bias
marginalized, Planck CMB prior

Factor 4.6 relative to Stage II



Method	$\sigma(\Omega_{DE})$	$\sigma(w_0)$	$\sigma(w_a)$	z_p	$\sigma(w_p)$	$[\sigma(w_a)\sigma(w_p)]^{-1}$
BAO	0.010	0.097	0.408	0.29	0.034	72.8
Clusters	0.006	0.083	0.287	0.38	0.023	152.4
Weak Lensing	0.007	0.077	0.252	0.40	0.025	155.8
Supernovae	0.008	0.094	0.401	0.29	0.023	107.5
Combined DES	0.004	0.061	0.217	0.37	0.018	263.7
DETf Stage II Combined	0.012	0.112	0.498	0.27	0.035	57.9

(these assume
Planck & Stage II
priors)



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BigBOSS Synergies: Cluster Science

- DES should identify 100,000 clusters with $M > 8e13$ to $z=1$, probably 200,000 with less conservative limits
- BigBOSS could identify BCGs for most clusters (to $z \sim ?$)
- This could be important in several ways:
 - more accurate redshifts
 - more accurate centering (main issue is mistaken BCGs at the wrong z)
 - SF & AGN activity in BCGs to beyond $z \sim 1$.
 - helps understand BCG formation, buildup of stellar mass, etc.
 - combine with SZ, X-ray helps understand coevolution of BCG & cluster gas, control systematics in the mass-observable relation



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BigBOSS Synergies: Supernovae Science

Chosen to maximize:

- visibility from DES site
- past observation history
- visibility from, e.g., Hawaii

Chandra Deep Field – South

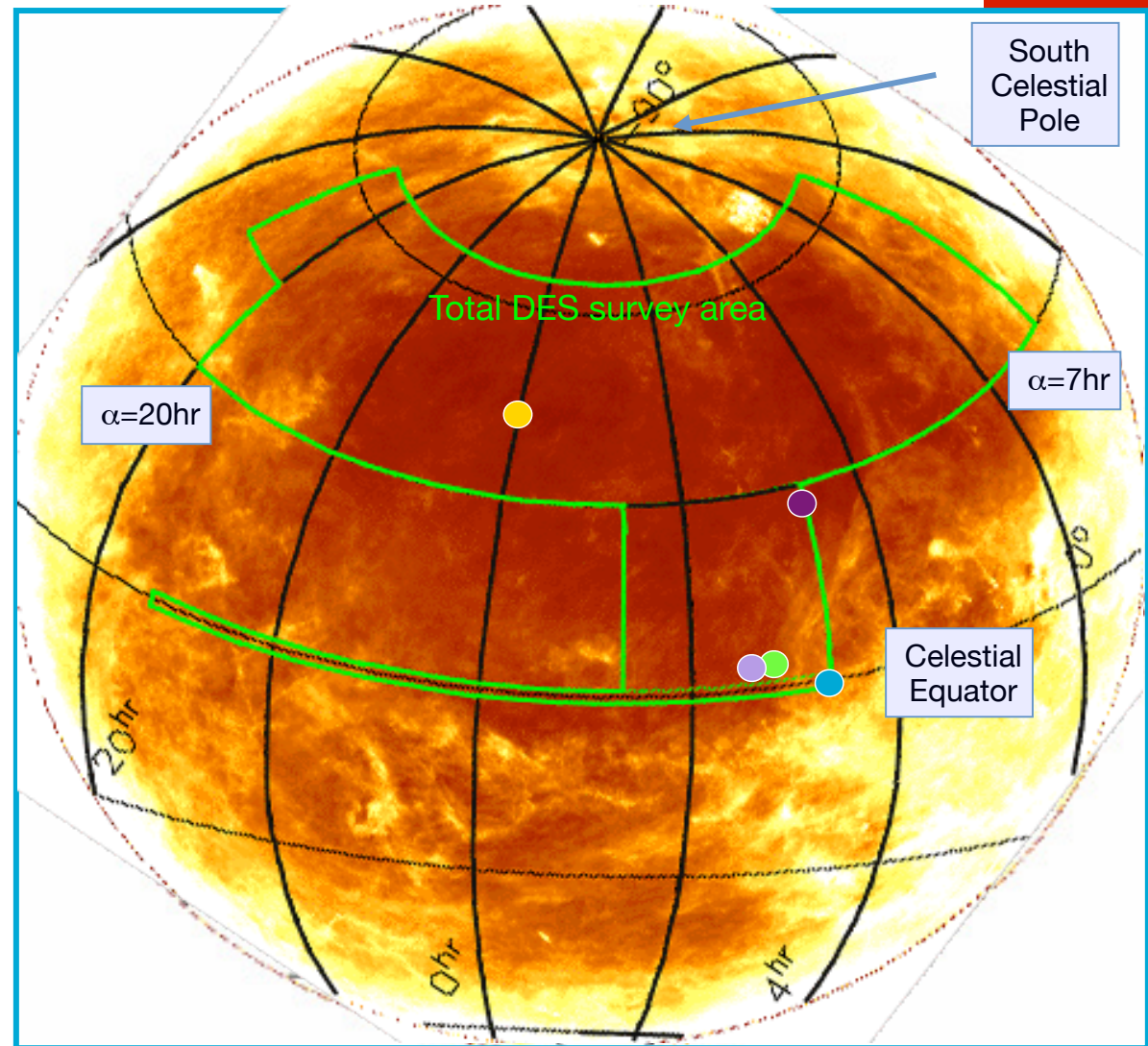
● Sloan Stripe 82

● SN Legacy Survey (SNLS) D1

● XMM-Newton LSS

● ELAIS S1

- Repeat observations of 15 deg^2
- ~ 3000 SN Ia lightcurves,
most in range $0.25 < z < 0.75$
- Larger sample, improved z-band
response compared to ESSENCE,
SNLS

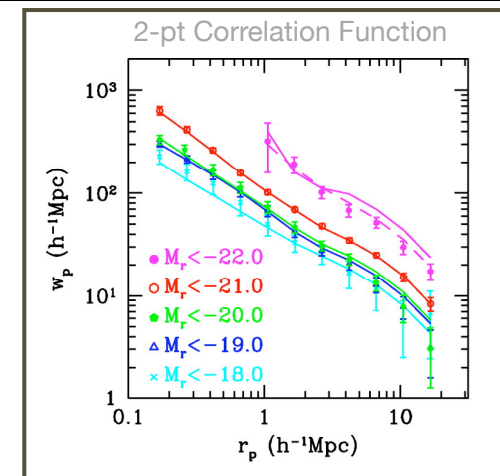
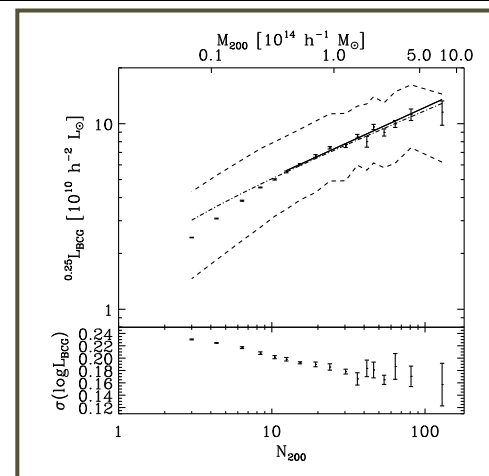
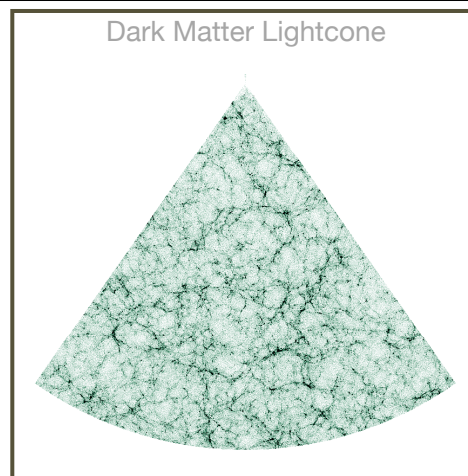
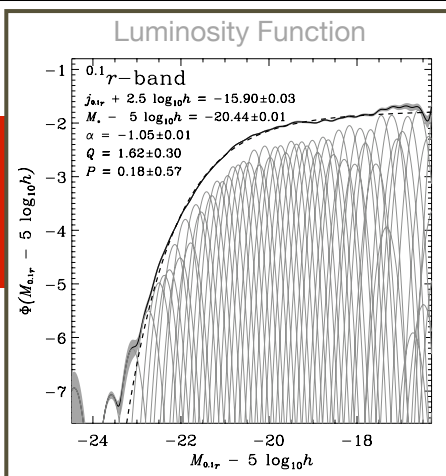


Alex Kim: 1 hr of BigBOSS time every 5 nights to monitor triggers from the DES supernova field can get the needed spectroscopy out to $z \sim 0.5$



DES Simulation and Mock Efforts

- Mature effort towards building realistic multi-wavelength mock catalogs
- several fronts:
 - large volume simulations with realistic galaxy colors to full DES depth
 - cluster finding
 - image simulations, input into DM system, being used by science working groups
 - photo-z pipelines
 - large suites of simulations including “galaxies” with correct z distribution (LSS)
 - intermediate volume simulations to full DES depth which include SZ data
 - using both hydro & semi-analytic SZ prescriptions + galaxies
 - early efforts towards joint SZ-optical cluster finding
 - simulations including baryonic effects
- Beginning efforts towards blind cosmology tests using mocks



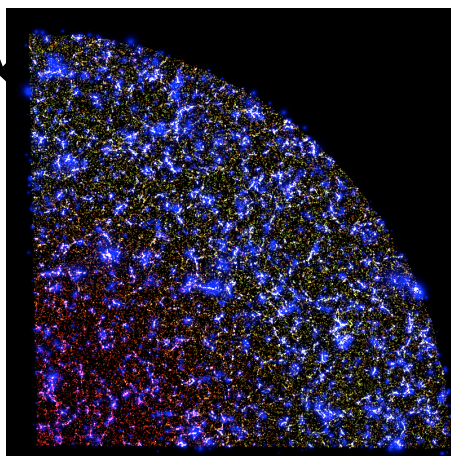
List of r -band
Galaxy
Magnitudes

Distribution of
dark matter
particles

BCG-halo
relation

$P(\delta m | M_r)$:
a relation between
galaxy magnitudes and
dark matter density

Assignment
of Galaxies
to Particles



+ colors
well tuned and modeled
at low z , excellent
agreement with SDSS
cluster sample

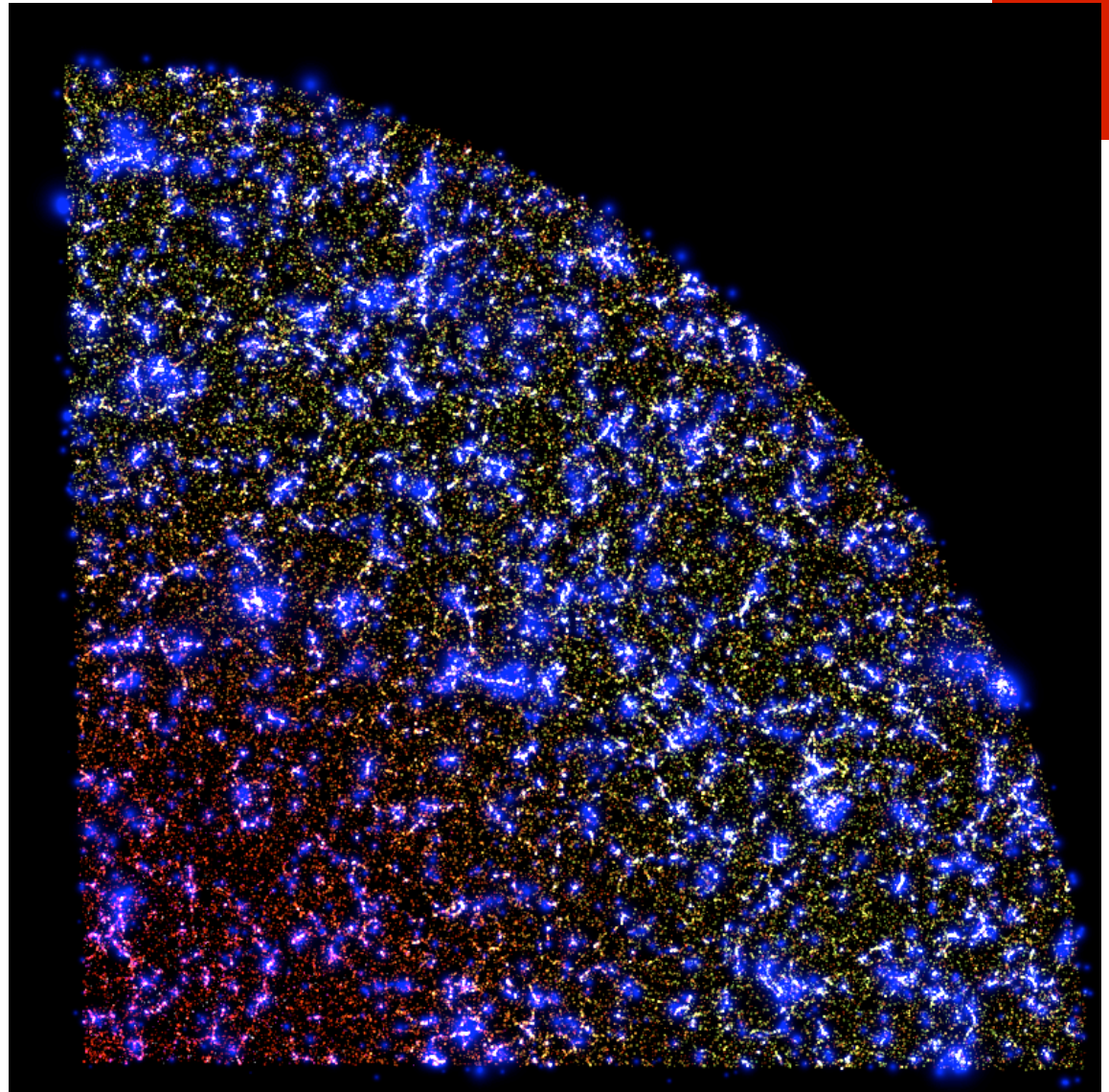
ADDGALS: Adding Density Determined Galaxies to
Lightcone Simulations
Bushman & Wechsler



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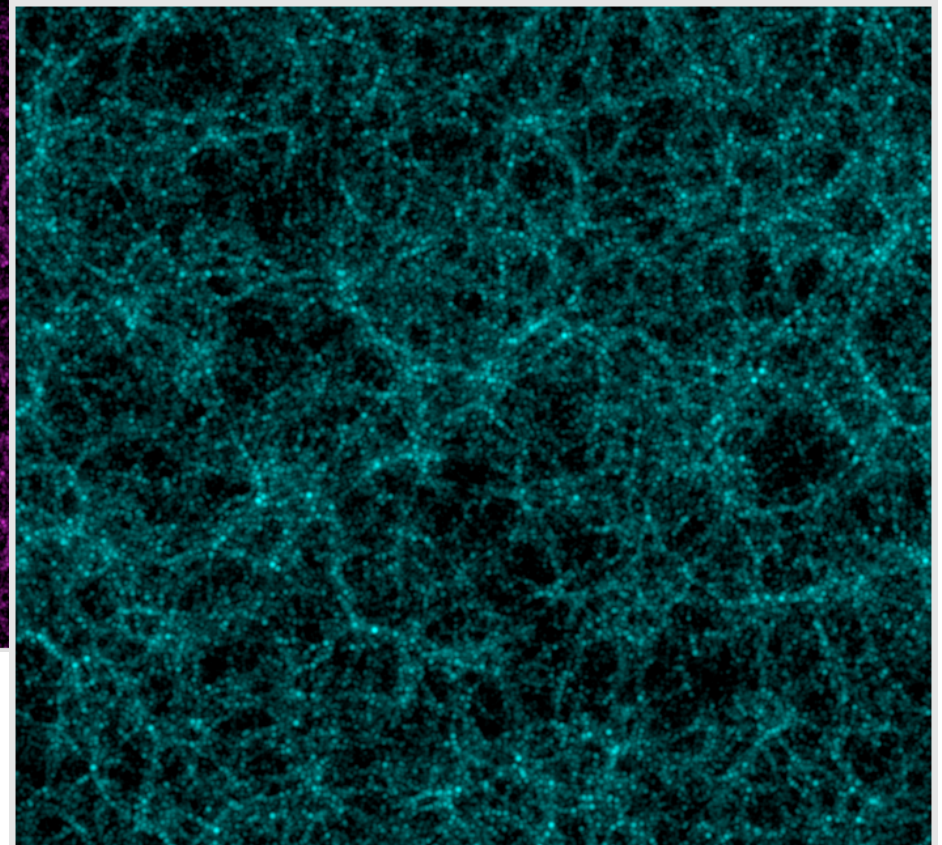
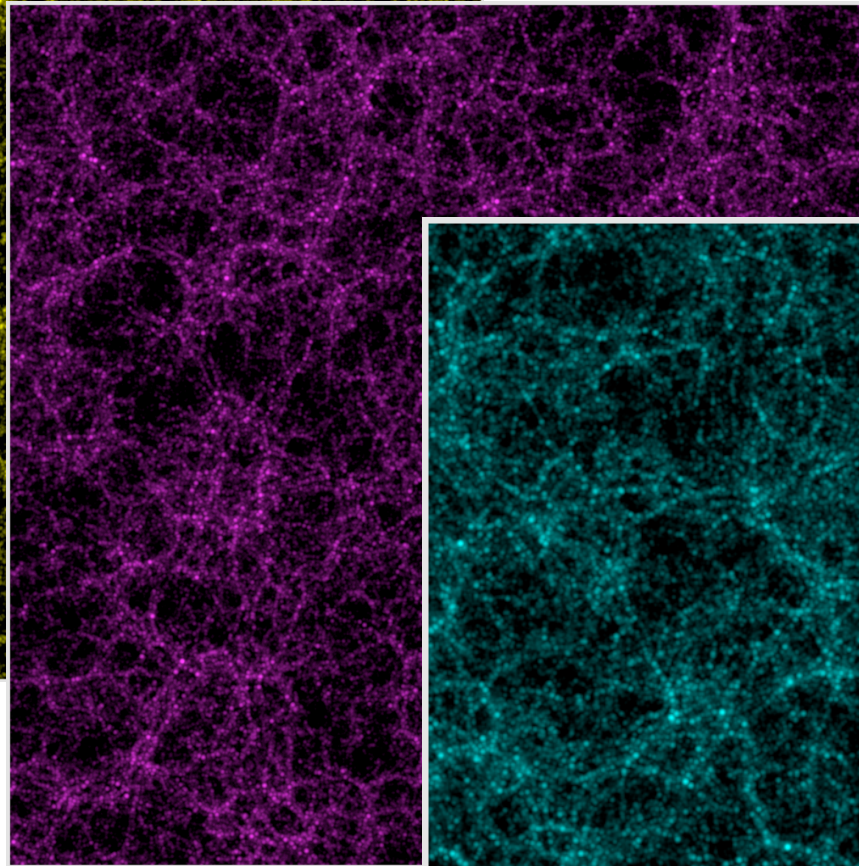
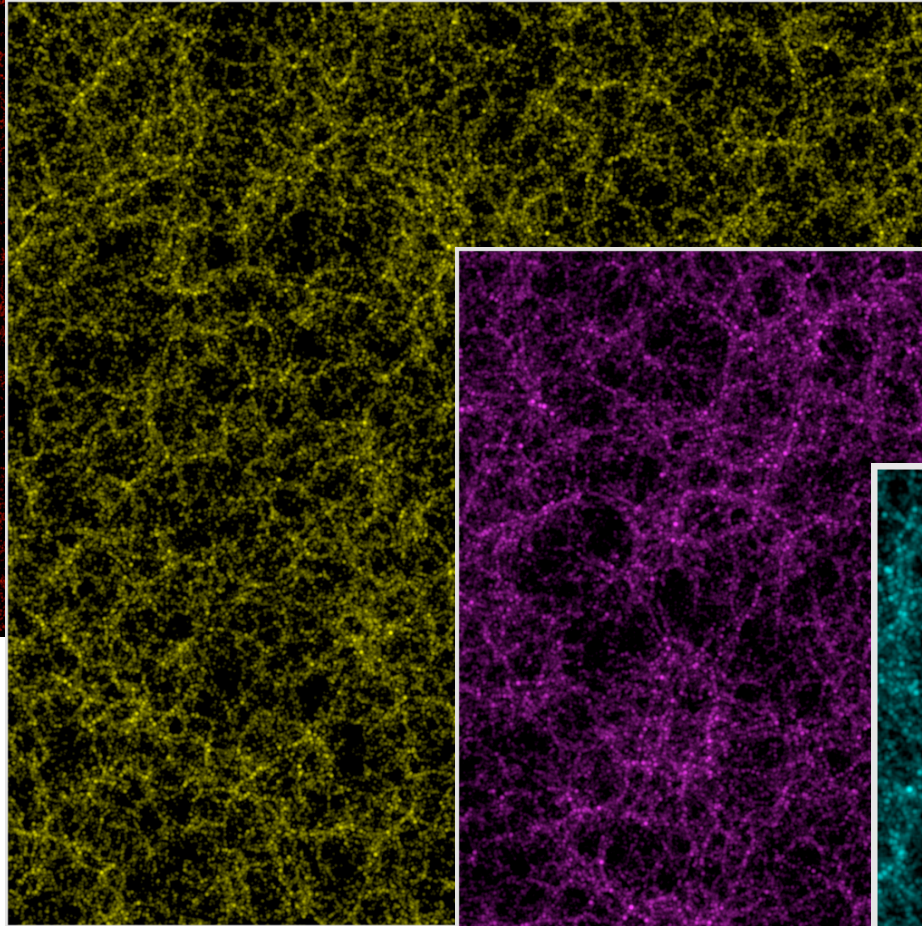
DES Mocks

- Full depth full volume catalogs
- Currently 250 sq. degree catalogs run through image simulation pipeline
- Actively testing and improving high redshift galaxies with current data.
- Note that these are largely empirically constrained, so they may not be predictive in regions with no data -- but using early DES data will provide accurate predictions for BigBOSS.



largest box gives full sky LRG
sample to $z \sim 0.45$
(quarter sky to $z \sim 0.85$)

200 boxes of 4 sizes from 420 to 2Gpc
designed to match SDSS samples
(-18 & -19, -20, -21, -22 & LRGs)
allows 100 surveys
for proper error analysis



LASDAMAS:

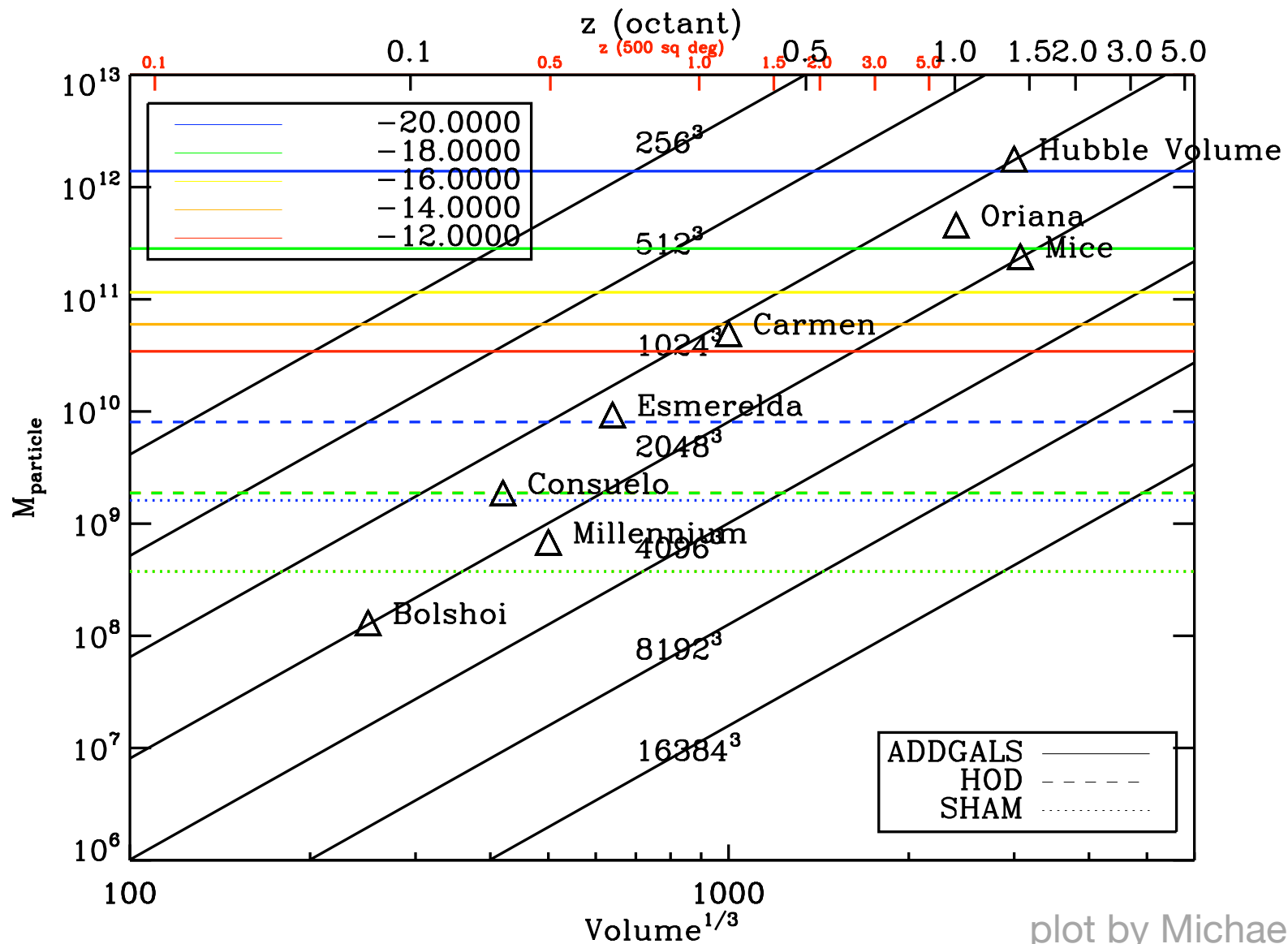
LargeSuite of Dark Matter Simulations

McBride & Berlind (Vanderbilt)

Busha & Wechsler (Stanford)

Scoccimarro (NYU)

The Simulation Challenge



plot by Michael Busha



DES Summary

- 5 year project, on track to start observations in October 2011
- baseline: 5000 deg² g, r, i, z, Y = 24.6, 24.1, 24.4, 23.8, 21.3
 - overlap with SPT (1200-2000 sq. degrees)
 - overlap with VISTA J, H, K VHS, VIKING
 - [VHS: 20000 deg²: 21.6, 20.6, 20.0;
 - VIKING: 1500 deg²: 22.1, 21.5, 21.2]
- deep SN survey 15 deg²
 - JHK from VIDEO: 15 deg²: 24.5, 24.0, 23.5]
- Mature and very active simulation effort including going all the way from N-body sims through imaging pipeline through (almost) to science analyses